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Human observers can easily detect a signal dot moving, in apparent motion, on a trajectory embedded in a background of random-direction motion noise. A high detection rate is possible even though the spatial and temporal characteristics(step size and frame rate) of the signal are identical to the noise, making the signal indistinguishable from the noise on the basis of a single pair of frames. The success rate for detecting the signal dot was as high as 90% when the probability of mismatch from frame-to-frame, based on nearest neighbor matching was 0.3 Control experiments showed that trajectory detection is not based on detecting a 'string' of collinear dots, i.e., a stationary position cue. Nor is a trajectory detected because produces stronger signals in independent 'local' motion detectors. For one thing, trajectory detection improves with increases in duration, up to 250 - 400 msec, a duration longer than the integration typically associated with a single motion detector. Moreover, the signal dot need not travel in a straight line to be detectable. The signal dot was as reliably detected when it changed its direction a small amount (<30 deg) each frame. Consistent with this, circular paths of sufficiently low curvature were as detectable as straight trajectories.

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RESEARCH OBJECTIVES

The major focus of our research program has been to determine how well human observers can detect moving targets in noise. We have set the visual system the extremely difficult task of detecting a single signal dot moving in apparent motion through a field of similar dots in random apparent motion. The spatial-temporal characteristics of the motion of the signal and noise dots are identical from frame-to-frame (same frame rate, same step size). The only difference is that the signal dot moves in a consistent direction for many frames. We found that detection is limited by the probability of a mismatch for a wide range of different scales. In biological terms, the probability of a mismatch is an indicator of the number of competing local signals that specify directions different from the direction of the designated signal dot. Apparently, the visual system copes with this competitive noise by a network in which the signals in adjacent motion detectors are enhanced if they are activated in sequence. The Grzywacz, Smith and Yuille model proposed such a network. Since real objects usually change direction rather slowly, this network will only respond if the change in direction between adjacent units is small. Consistent with this prediction, Watamaniuk, McKee and Grzywacz showed that circular motion is just as readily detected as straight motion, provided that the curvature of the circle is shallow. In a second paper, Grzywacz, McKee and Watamaniuk are using the temporal coherence model to predict the experimental results. A third study examining the influence of blur (low-pass filtering) on these patterns is in progress.

Thus far, the signal and noise have been confined to two dimensions. Obviously, natural objects move through three dimensions, so to simulate more natural conditions, we have begun studying signal detection for consistent trajectory motion in a three-dimensional array of random noise dots. We created a three-dimensional stereoscopic display by presenting noise on two CRT screens. The images on these screens were combined via a beam-splitter. Orthogonal polarizers placed in front of the screens and the subject's eyes guaranteed that only one screen was visible to each eye. The random disparities between the dots on the two screens produced a three-dimensional percept of three dimensional motion noise. We then presented a single dot moving in depth obliquely along one of eight trajectories. Signal detection in the three-dimensional noise was not much better than performance during binocular viewing of one of the two screens (two-dimensional noise). This result is surprising because it is thought that one function of stereopsis is breaking camouflage. Apparently stereo does not confer much benefit for fine-scale motion detection. We are presently exploring the reason for our results. These findings will be presented at the annual ARVO meeting.

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PUBLICATIONS

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